

**A DECADE OF NASA/JSC STRATOSPHERIC DUST COLLECTION: NONSPHERICAL CHONDRITIC INTERPLANETARY DUST PARTICLES.** Frans J.M. Rietmeijer, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 97131, USA.

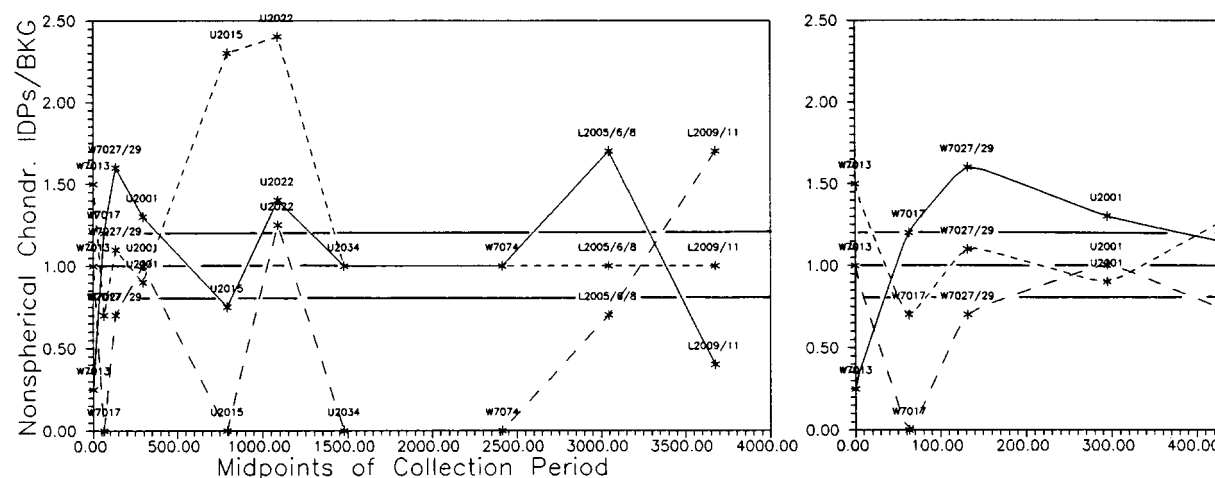
From 22 May, 1981 to 11 July, 1991 the still ongoing NASA/JSC Cosmic Dust Program has collected dust in the stratosphere between 17-19 km altitude, generally over the western US up to Alaska with excursions along the Pacific coast down to the equator. Each particle is identified by a scanning electron microscope image, an energy dispersive spectrum, several optical properties, and its size and is listed in the Cosmic Dust Catalogs 1-14 and in Cosmic Dust Couriers. The curator's office has established criteria to identify the particles [1] but these identifications are not definitive. Still, ten years of collective experience showed that the "C" (cosmic) labels is used consistently and confirmed by subsequent petrological and chemical analyses albeit that rare errors occur [2]. It is possible to use this database to study intra- and interannual trends in the abundances of interplanetary dust particles (IDPs) [3].

**DATABASE.** I report results of a survey of nonspherical chondritic IDPs in these NASA/JSC catalogs except vol. #6. I excluded chondritic rough IDPs that are unique to the large area collectors (LACs; 300 cm<sup>2</sup>) and the S-free rounded chondritic filled [CF] IDPs on two small area collectors (SACs; 30 cm<sup>2</sup>) [3]. I generally accepted the curator's identification. I rejected a few "C" IDPs as "TCN" (terrestrial contamination natural; mostly volcanic ash) but I upgraded a few "C?" particles to "C". For data reduction of these IDPs I used  $D_a = (a+b+c)/3$ , where  $a > b > c$  are three particle dimensions;  $a$  and  $b$  are from the catalogs. I assume  $c = 0.8b$  which is supported by actual IDP size measurements [cf. 4]. The Cosmic Dust Program uses both SACs and LACs and in order to compare particle abundances, the amount of IDPs on the LACs is divided by 10<sup>0.5</sup>. There is no apparent bias due to use of different collectors [2,3].

**RESULTS.** The sizes of individual nonspherical chondritic IDPs define three populations (i) 2-9 μm, (ii) >9-19 μm, and (iii) >19 μm. The first two are normal distributions. The third one is typically too small to define any distribution type. The collection times of individual collectors are variable and require a normalization procedure for comparison of abundances. The SACs U2034 and W7074 collected dust during narrow slots of 30.7 h and 32 h, resp. over periods of several months (U2034) to almost a year (W7074) [2]. These slots have limited overlap with the slots for other collectors. I submit that IDP abundances on these two SACs define a **background** (BKG). The IDP abundances on collectors with the longest (65 h: W7013) and shortest (31.4 h: U2001) exposures may also constrain this BKG. Both methods give similar results with errors of 10-20% relative in calculated BKG levels. The BKG levels for these IDPs are: 0.19 p h<sup>-1</sup> (2-9 μm) and 0.23 p h<sup>-1</sup> (>9-19 μm) that are used to obtain normalized abundances as a function of IDP size on each collector. The results (Figure 1) are (i) IDPs (2-9 μm) occur at the BKG level; above BKG on W7027/29 & L2005/6/8, below it on W7013 & L2009/11, (ii) IDPs (>9-19 μm) have BKG levels but above it on W7013, U2015 & U2022 and (iii) IDPs (2-9 μm) are more abundant than IDPs (>9-19 μm) on W7017, U2001, W7027/29 & L2005/6/8 and (iiib) the inverse situation occurs on U2015, U2022, W7013 & L2009/11. The SACs W7027/29 & LACs L2005/6/8, while W7013, U2015, U2022 & L2009/11, are paired, *i.e.* they sampled the lower stratosphere during similar periods of the year [3]. Relative IDP abundances correlate for paired collectors. Low abundances of small IDPs (2-9 μm) relative to those >9-19 μm could reflect IDP survival during atmospheric entry heating [5], or the preferential association of small IDPs with cluster IDPs and which thus do not reflect true meteoroid abundances in this size range. Many IDPs are listed as cluster fragments, or as "associated with" that I accept to indicate clustering. The main change in IDP abundances after cluster allocation is a smoothing of the abundances of IDPs < 20 μm to the BKG levels [2]. There is indeed a trend favoring allocation of small "unbound" IDPs in the collection to clusters. The impact of cluster allocation these IDP abundances is dramatic on the LACs but it is not reflected by their paired SACs.

**ATMOSPHERIC ENTRY.** The minimum size of an IDP that can survive atmospheric entry heating is conservatively estimated at ~10 μm [5,6]. Many "unbound" nonspherical chondritic IDPs show features that I interpret as atmospheric entry heating, *viz.* (i) a smooth transparent surface layer, (ii) thin discs and filaments at the surface, and (iii) an 'equatorial' collar surrounding the IDP. These presence of these features may correlate with the carbon content (Brownlee, pers. comm., 1993). I stress that these thermal indicators are qualitative. The size distribution of heated "unbound" IDPs drops off sharply at 10 μm after removal of carbon-rich IDPs (high bremsstrahlungs BKG). The remainder is a skewed normal distribution (mean = 16.6 μm; std. dev. = 6.3 μm; mode = 11.0 μm) consistent with decreasing abundances towards larger IDPs. The drop-off at 10 μm matches the model assumptions [5,6] but a population of IDPs 5 <  $D_a$  < 9.5 μm (mean = 7.4 μm) shows there is a size range wherein competing heating due to lowered emissivity and enhanced survival of small IDP masses contribute to IDP survival. The carbon-rich IDPs are between 1.9 and 7.4 μm (mean = 5.4 μm; mode = 3.3 μm). Their carbons promoted entry survival as was suggested for carbon-rich micrometeorites [7]. The highest proportions of heated "unbound" IDPs (mostly > 19 μm) occur on W7027/29 (76.5%) and L2005/6/8 (88%) (during early October), and on L2009/11 (93.5%) (late May till August).

## A DECADE OF DUST COLLECTION: F. J. M. Rietmeijer



**FIGURE 1:** Normalized abundances of nonspherical chondritic IDPs as they occur on the collectors, that sampled the lower stratosphere between 22 May, 1981 to 11 July, 1991 as a function of the midpoints of the collection period of each collector whereby the first day is May 22, 1981 for particles 2-9  $\mu\text{m}$  (solid line), >9-19  $\mu\text{m}$  (fine dashed line), and >19  $\mu\text{m}$  (coarse dashed line). The horizontal lines indicate the background % 20%. The lines connecting individual collectors merely serve to guide the eye but CANNOT be used to define continuous trends in these IDP abundances.

**CONCLUSIONS.** The NASA/JSC Cosmic Dust Catalogs are a rich source of information on the abundances of nonspherical chondritic IDPs that survived atmospheric entry. After removal of IDPs that occur in cluster IDPs, these "unbound" IDPs occur close to background levels for IDPs (2-19  $\mu\text{m}$ ), or less for IDPs (2-9  $\mu\text{m}$ ). It is not yet clear that apparent higher abundances of cluster IDPs on the LACs compared to SACs is not an experimental or a curatorial artifact. The size distributions of "unbound" IDPs support (1) a transition in atmospheric entry survival of IDPs between 5-11  $\mu\text{m}$ , (2) survival of small (<10  $\mu\text{m}$ ) carbon-rich IDPs, and the abundance of cluster IDPs is severely underestimated which has important ramifications for IDP survival and the nature of their parent bodies.

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